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EDITOR,

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School of Mines, Columbia College, N. Y. City.

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change of shape of the entire mass of the unicellular body. The power of movement here resides in the unorganized protoplasm, without any organs whatever. Even in the lowest form of life there is a conversion of *Vital* force into *Physical* force.

Higher in the animal scale we find motion by means of cilia. These are minute elastic filaments which have a whip-like motion—alternate flexion and extension. But the cilia do not seem to be controlled necessarily by the creature's will. The motion is evidently automatic. Many low plants, as well as animals, have the body covered with cilia by which they tumble about in the water very lively. In some of the infusorians, however, the cilia seem to obey the animal's will.

The means of motion in all higher animals is muscular tissue. This is a highly specialized tissue, subjected to the nervous system, and which concentrates the power of movement, which in the amoeba was diffused through the whole mass of the body. Muscular power resides in the contractility of the cells. Expansion of the cells or the extension of the whole muscle is produced by elastic reaction—a merely physical force—or by contraction of opposing muscles. Muscles act under nervous, electric or other stimulus; but sometimes no stimulus seems necessary.

The organs and methods by which the vital contractile force of muscular tissue is utilized in producing mechanical power is a most interesting study. [With the magic lantern a few of the more typical and interesting methods of locomotion in animals were shown.]

A few animals move without organs, as the sea-anemone in crawling or the jelly-fish, leech, and snake in swimming. But most animals have parts or organs specially adapted to locomotive purposes. The old classification of swimming, flying and walking will answer our purpose.

Locomotion in water requires much less effort than locomotion in the air, and more than locomotion on solids. But the organs for swimming are comparatively simple. The lobster swims backward by its tail fin, which is a combination of beautiful oars. The squid swims in any direction, by ejecting the water of respiration out of a flexible tube.

Swimmers *par excellence* are the fishes. They propel themselves chiefly by their tail fin, used as a horizontal scull oar. The remaining fins are used to guide and control the motion. The paired fins are based upon the arm and leg bones. The rays fly through the water by means of the pectoral fins and side expansions of the body. The whale propels himself by the vertical motion of the body and tail Frogs, turtles, crocodiles and many birds are especially adapted to a life in water.

Locomotion in Air.—On account of the extreme rarity of the atmo-

sphere, flight requires special apparatus and structure and very great muscular power. But insects and birds outstrip all other creatures. Their whole structure is wonderfully adapted to aerial life; the skeleton light, the body filled with air, the wings elastic and light, but firm, and the wing muscles exceedingly powerful. Wings of birds are quite similar in principle and structure, but wings of insects greatly differ. Three classes of insect wings may be noticed: the transparent wings of the bee, fly, etc.: the dense opaque wing covers of the beetles: and the scale-covered wings of the butterfly and moth.

The wing of the bat is an expansion of skin stretched upon the long fingers and from arm to leg. Dragons passed away with the age of reptiles. The so-called flying dragon has only a parachute of expanded skin, by aid of which it can sail downward through the air. The flying squirrel has a similar apparatus. In the flying-fish, the pectoral fins are very large, and serve a similar purpose. Some spiders are able to sail the air by means of kites or sails made of their silken webs.

Locomotion on Solids.—A much greater variety of organs are used for moving on solids. The leech, star-fish and cuttlefish employ suckers, which are little cupping glasses or diminutive water-pumps. The earth-worn has minute spines, and the serpent large scales or scutes on its belly; caterpillars have pins rather than legs. The foot of the clam is a fleshy protuberance which can be pushed into the sand, enlarged at the end and then shortened. The snail glides over the surface by sets of short muscles in the under side of its body; flies adhere by a fluid, exuded by the hairs on the surface of their foot discs.

Of jointed limbs the millipede has, in some species, two or three hundred. The centipede has thirty or forty legs; crabs and lobsters have ten legs, but two used as pincers. The spider has eight legs, and the true insects have six legs. The reduction in the number of similar organs indicates advance in locomotive powers.

As the skeletons of all vertebrates are built on the same general plan, the four limbs of all show a certain resemblance; of course, the similarity is most evident in the legs of quadrupeds.

The limb bones of fishes are in nearly all cases within the body, as the basis of the paired fins. But in some fishes they are sufficiently developed to be useful for crawling. In reptiles the limbs are generally awkward on land, although some lizards are agile. The legs of birds are highly specialized.

While mostly intended for running on land, the mammals nevertheless exhibit a greater diversity of organs and methods of locomotion than any other class of animals. Here we find the swimming whale and seal, the flying bat, the sailing lemur and squirrel, the creeping

sloth, the jumping kangaroo, the swinging monkey and the swift running quadrupeds.

The arms and legs of the running mammals are highly developed, and the mechanical construction and action of the parts are beautiful and wonderful. The muscles of the body are largely grouped about the shoulders and hips.

The arms are usually straight, but in the swifter animals, as the deer and horse, the legs are considerably bent. In the elephant the legs are straight columns supporting the huge body.

The normal number of phalanges is five, but there is great variation. The hoofed quadrupeds may have three, as the rhinoceros: two, as the ruminants: or one, as the horse. Some mammals walk on the whole sole of the foot, as the bear and man, termed plantigrade; others on the toes, as the cat and dog, digitigrade; while the foot of the seal is termed pinnigrade, and the hoofed quadrupeds, ungulate.

May 15, 1882.

LECTURE EVENING.

The President, Dr. J. S. NEWBERRY, in the Chair.

The hall was filled by a large audience.

The closing lecture of the monthly course for the season was delivered by Prof. H. CARRINGTON BOLTON, Ph. D., of Trinity College, Hartford, Conn., on the subject of

GLACIERS.

The lecturer treated of the chief glacier regions, especially those of the Alps, of the various physical phenomena presented by them, of the several theories of ice motion, and of personal experiences in travelling among glaciers, illustrating the whole with a varied and striking series of photographic lantern views.

May 22, 1882.

SECTION OF GEOLOGY.

The President, Dr. J. S. NEWBERRY, in the Chair.

Twenty-two persons present.

Prof. O. P. HUBBARD, exhibited a peculiar organic salt, malate (or, perhaps, bi-malate) of lime, from Williamstown, Vt., derived from the sugar-maple. In the manufacture of the sugar,

the syrup, when ready to crystallize, is strained through a flannel filter, and this substance is thus obtained, as a fine white or buff crystalline powder. He had long known it, as obtained rarely and in small amounts at Hanover, N. H., in the mica-slate region ; while from the towns in Vermont, where the rocks are more calcareous, it is common and abundant. At Williamstown, there are springs that deposit calcareous tufa.

The substance is popularly called "sap-sand" and "sugar-nitre ;" in Steele's "Fourteen Weeks in Chemistry," it is referred to as *silica !*

The PRESIDENT remarked upon the power of plants to select their food from the soil, and to form organic salts by laws and processes as yet largely unknown to us.

Various minerals were exhibited by Mr. G. F. KUNZ and Mr. W. L. CHAMBERLIN.

Capt. J. H. MORTIMER showed specimens of granite, compact and disintegrated, and of the resulting kaolin, from the Island of Jersey ; also, a specimen of the red syenite, of the Egyptian obelisk set up on the banks of the Thames, similar to the one now here.

The subject of the disintegration of granites and the production of kaolin, was further remarked upon, and examples cited from various localities [Mystic, Conn., the White Mountains and New York Island], by the PRESIDENT, Prof. O. P. HUBBARD and D. S. Martin.

A paper by Mr. ISRAEL C. RUSSELL, was then read by Prof. MARTIN, entitled :

SULPHUR DEPOSITS IN UTAH AND NEVADA.

Sulphur deposits of sufficient extent to attract attention from their economic importance have been visited by the writer at three localities in the Great Basin. These are located at Cove Creek, Millard County, Utah ; near Humboldt House, Humboldt County, Nevada ; and at Rabbit Hole on the eastern edge of the Black Rock desert in Northwestern Nevada.

Sulphur Deposits at Cove Creek.

Of these deposits, the most interesting to the geologist are those occurring at Cove Creek in Southern Utah. This locality is on the eastern border of the Great Basin and at the western edge of the region of the high plateaus recently described by Captain DUTTON. Eastward is a

high range of trachytic mountains, that sweep around to the northwest and southeast, forming a crescent-shaped alcove in the western face of the range, the points of which are about ten miles apart. Between the horns of this crescent, and three or four miles southwest of the Ranch Fort at Cove Creek, is a conical mountain of basalt, having the ruins of a cinder cone at the summit; for convenience we shall call this old volcano the Cove Creek crater. From the perfection of its outlines, this crater seems to be of a very recent date, but is clothed with a scattered growth of cedars. Judging from its general appearance and the amount of weathering it has suffered, it is probably older than the post-Bonneville craters near Fillmore, Utah. The Cove Creek crater is now in the condition of a nearly extinct fumerole, as hot air and gases are said to escape from cracks and fissures near the summit of the mountain. The area, between the base of the crater and the mountains to the eastward of Cove Creek, is occupied by subaerial gravels, except along the immediate base of the eastern range, where volcanic tuffs appear at a number of localities. Along the line where the alluvium slopes upward to meet the tuffs and volcanic rocks, is where the majority of the sulphur mines have been opened.

Prospecting for sulphur was begun at Cove Creek, about ten years since, by Mr. C. A. SEMLER, and has been carried forward by him with much energy ever since. At the present time fifteen mines have been located, a few of which have been developed to a slight extent, and a large number of prospects opened. The mines, however, have not yet been worked sufficiently to make the sulphur from this locality an article of commerce.

From the hasty examination that I was enabled to make, I find tha the sulphur deposits at Cove Creek arrange themselves in three convenient groups, the divisions depending, however, more on the nature of the cavities that have received the sulphur, than on any difference in the manner in which it has been introduced. In one instance the sulphur occupies a nearly extinct solfatara; again we find it impregnating and cementing beds of volcanic tuff; at other times, the sides of fissures are sheathed with a brilliant drusy lining of sulphur crystals. In all of these instances it is evident that the sulphur has been derived from deeply seated sources, having been expelled in a gaseous form and condensed and crystallized in the cavities and fissures in the cooler rocks above.

In the mine named the *Cleveland* by Mr. Semler, situated about two miles southward of the fort at Cove Creek, the sulphur occurs in quantity, filling the crater of a solfatara. The bottom of the little valley, in which the Cleveland is situated, is nearly circular, with a diameter of about 1200 feet, and is totally destitute of vegetation. Over the level

surface of the strange little desert the sulphur outcrops in many places, forming ledges of sulphur; and a number of prospects show an abundance of quite pure material. A shaft was sunk in the centre of this deposit, to the depth of twenty-five feet, all in pure sulphur, as I was informed by Mr. Semler. The material taken from this shaft has been returned to it, in order to guard against the burning of the mine, and the broken fragments are now cemented into a solid mass by the sulphur that has been deposited in the interstices between the broken masses. The deposition of sulphur is still in progress, the prospecting holes becoming lined in a few days with most beautiful plumb-like crystals of pure sulphur. The temperature in all the openings in this sulphur bed is high. At the surface of one of the prospecting holes which had been refilled with broken fragments, the thermometer read 104° F.; and through all the openings vapor and heated gases are constantly escaping. In cold weather the clouds of vapor forming above this mine may be observed from a distance of a mile or two. The drops of moisture that condense on any cold object held for a moment in the excavations, are intensely acid, and from their taste seem to a contain a large proportion of sulphuric acid. No chemical examinations of these acid drops or of the gases that are constantly escaping from the openings could be made. It is noticeable, however, that no odor of sulphuretted hydrogen can be detected about the mines; but from a few simple tests, and from the presence of dead animals in a large number of the openings, it seems evident that carbonic acid is exhaled in large quantities. The sulphur at this locality covers a circular area of about 1000 feet in diameter, and, from the prospects that have been reported, cannot be less than twenty-five feet thick. This is not pure sulphur, however, but certainly carries a large percentage of earthy matter.

The conclusion arrived at, from a hurried inspection of this interesting locality, is that the sulphur fills a nearly extinct solfatara, into which it has been conducted from below, seemingly by direct sublimation, or, what is perhaps more probable, by the decomposition of sulphurous gases, and the deposition of the liberated sulphur. A careful examination of the fumes that are exhaled from these openings would certainly be of much value in determining the chemical history of sulphur deposits.

Of the second class of mines—those in which the sulphur impregnates beds of volcanic tuff—we have examples in the *Mariposa* and *Prince Albert*, situated at the base of the mountains, two miles east of the fort at Cove Creek. At these localities the tuff is stratified, and contains scattered pebbles of quartzite and limestone, and is impregnated over a large area with sulphur, which fills all the interstices of

the rock. Judging by the eye alone, much of the tuff contains from ten to forty per cent. of sulphur, while in localities the rock is far richer than this. Overplacing the tuff are alluvial cones of gravel, that are in some places cemented by sulphur in the same manner as the strata of tuff beneath, thus showing that the beds now carrying the sulphur have acted simply as condensers for the sulphur, which in every case has been derived from a deeper source.

The third class of sulphur deposits—those in which the sulphur forms a lining of crystals on the sides of fissures—are illustrated by the *Philadelphia* and *Mammoth* mines. At the first of these, situated one mile north of Cove Creek, the sulphur occurs in drusy crystals covering the sides of small intersecting fissures in trachyte. The rock has here been much broken along a line of faulting, which may be traced southward to the top of the Cove Creek crater. The Mammoth mine is of a similar character, but found in dark carboniferous limestone. This mine is located on the top of the divide between Cove Creek and Dog Valley to the northward. While standing on this pass, the line of faulting, on which the Mammoth mine is situated, may easily be traced southward to the valley of Cove Creek; and across the valley it is again seen as a bold fault-scarp, with a throw to the westward, ascending the side of the volcanic crater that we have already mentioned several times. The fault crosses this cone just to the east of the summit, and has given the eastern slope of the mountain a steeper inclination than is shown by the western side. Northward from the Mammoth mine the same line of faulting is continued for many miles, and shows a recent scarp all along the eastern border of Dog Valley. The fault-scarp that ascends the side of the volcanic cone, and also the recent scarp in Dog Valley, are the results of slight and very recent movements along an ancient line of profound displacement. The volcanic mountain southwest of Cove Creek has been built over this old line of fracture. The sulphur in the Mammoth mine has been deposited in the fissures made by the faulting of the strata, and in the seams and openings between the layers of limestone. The rock on the borders of these fissures, beneath the thin lining of sulphur, has been altered to a brown earthy mass, to the depth of about half an inch. The mines, like the Philadelphia and Mammoth, that have been opened on lines of fracture in solid rock, show but little sulphur, and on the whole cannot be considered as giving promise of any large deposit below the surface. In these mines also the temperature is high, but not so great as at the Cleveland.

The beds of volcanic tuff, in which the sulphur has been deposited, probably rest on harder rock that has been fissured, thus allowing the sulphur-bearing vapors to escape upwards, as in the case of

the Philadelphia mine; but no section showing the tuff beds above such fissures has been exposed. As these beds of tuff occur for many miles along the base of the mountains, we may hope that the conditions for charging them with sulphur have been many times repeated. Next to the Cleveland mine, we should certainly look to the beds of tuff, along the base of the mountains eastward of Cove Creek, for the principal supply of sulphur for economic purposes from this region.

Owing to the exhalation of noxious gases in nearly all the prospects that have been opened, we find in the bottoms of the excavations large numbers of dead insects, together with the remains of mice, bats, rabbits, etc., that have been smothered by the escaping gases. In many of the openings a choking sensation is felt, and the amount of gas, which seems to be largely carbonic acid, is so great that a person can remain in them but a few seconds. Even in shallow prospects the workmen have to fan each other, in order to remain in the openings long enough to do their work. These mines can only be opened from the surface, and even by this method they cannot be worked to any considerable depth, owing to the high temperature of some of the prospects and the constant escape of noxious gases.

Associated with the deposits of sulphur are beds of gypsum, and also irregular deposits of "alum." Just what the nature of this "alum" may be has not been determined by analysis. These beds usually overlie the sulphur deposits, the alum being sometimes two feet thick, and the gypsum as much as eight feet. Hot springs occur in the same field, which, together with the feeble fumerole at the top of the old crater, bear evidence of the expiring volcanic energy of the region.

Sulphur Deposits at Humboldt House, Nevada.

The sulphur at this locality has been reported as occurring in nearly vertical fissures that are associated with recent basaltic buttes. Careful search was made by the writer, however, for fissures answering these conditions, while examining the surface geology of the Humboldt Valley, without successful results. The only sulphur deposits that could be found in the vicinity, and the only ones known to the people living at Humboldt House, occur in the craters of extinct hot springs. These craters are situated about half a mile southward of Humboldt House, on the open sage-brush desert, and rise to the height of from twenty to fifty feet, as nearly as could be estimated. Nearly all of the cones are weathered and broken down, and all are extinct, the water now rising to the surface for miles around. The outer surface of the cones is composed of calcareous tufa and silicious sinter, forming irregular imbricated sheets that slope away at a low angle from the orifice at the top. The interiors of these structures are filled with crystalline gypsum, that

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in at least two instances is impregnated with sulphur. One of the cones has been opened by a cut from the side in such a manner as to expose a good section of the material filling the interior, and a few tons of the sulphur and gypsum removed. The percentage of sulphur is small, and the economic importance of the deposit, as shown by the excavation already made, will not warrant the further expenditure of capital. The cone that has been opened is surrounded on all sides by a large deposit of calcareous and silicious material, thus forming a low dome or crater, with a base many times as great in diameter as the height of the deposit.

These cones correspond in all their essential features with the structures that surround hot springs that are still active in various parts of the Great Basin, thus leaving no question as to their origin. They are situated within the basin of Lake Lahontan, and must have been formed and become extinct since the old lake evaporated away.

Sulphur is reported as occurring in the chemically formed deposits that surround Steamboat Springs, situated midway between Carson and Reno, Nevada. The conditions at these springs must be very similar to what existed near Humboldt House, at the time the cones containing the sulphur were formed.

Sulphur is also said to occur in the Sweetwater Mountains, situated on the boundary between California and Nevada, in latitude 38° 30′; the extent and geological relations of these deposits are unknown.

The Rabbit Hole Sulphur Mines.

These mines are located in northwestern Nevada, on the eastern border of the Black Rock Desert, and derive their name from the Rabbit Hole Springs, a few miles to the southward. The hills bordering the Black Rock Desert on the east are mainly of rhyolite, with a narrow band of volcanic tuff along the immediate edge of the desert. These beds of tuff are stratified and evidently water-laid, and are identical with tuff deposits that occur over an immense area in Oregon and Nevada. At the sulphur mines, the tuffs contain angular fragments of volcanic rock and are cemented by opal and other silicious infiltrations since their deposition, so that they now form brittle silicious rocks with pebbles and fragments of older rocks scattered through the mass. In many places these porous tuffs and breccias are richly charged with sulphur, which fills all the interstices of the rock and sometimes lines large cavities with layers of crystals five or six feet in thickness. In the Rabbit Hole district, sulphur has been found in paying quantities for a distance of several miles along the border of the desert, but the distribution is irregular and uncertain, and is always superficial, so far as can be judged by the present openings. As in the Cove Creek mines, the sulphur at

Rabbit Hole has been derived from a deeply-seated source, and deposited from a vaporous condition, in the cooler and higher rocks in which it is now found. Judging from the silicious material that cements the tuffs, it is evident that the porous rocks, in which the sulphur is now found, were penetrated by heated waters bearing silica in solution, previous to the deposition of the sulphur. These mines occur in a narrow north and south belt, along a line of ancient faulting which is one of the great structural features of the region. The association of faults, with sulphur bearing strata of tuff, is here essentially the same as at the Cove Creek mines. At the Rabbit Hole mines, however, no very recent movement of the ancient fault could be determined. This absence of a recent fault-scarp, together with the fact that the mines are now cold and do not give off exhalations of gas or vapor, shows that the solfataric action at this locality has long been extinct.

At all the localities visited, the sulphur has been derived from sources far beneath the surface, from which it has been expelled by heat, and escaped upwards through fissures that were formed along lines of faulting, and has been condensed on the sides of fissures and in the interspaces of the cooler rocks near the surface. Whether the deposition of the sulphur took place by direct sublimation, or by the decomposition of sulphuretted hydrogen, has not been determined. The date at which the sulphur was introduced into the rocks, where we now find it, is in all cases very recent, and at the Cove Creek mines the action is still in progress.

Work at the Rabbit Hole mines is now being carried forward by a day-shift of seventeen men, the production of sulphur being about six tons per day. The value of the sulphur produced is about forty-five dollars per ton in San Francisco. The sulphur, after being mined and assorted, is placed in upright cast-iron retorts, having a general resemblance to the common form of blast furnace, with a capacity of about two and one-half tons. When the retorts are charged, the opening at the top, through which the sulphur bearing rock is introduced, is closed, and superheated steam admitted at the side. The steam pressure is at first about seventy pounds to the square inch; but, as the sulphur begins to melt, the pressure is allowed to subside to sixty or perhaps fifty pounds. When the sulphur melts, it passes through a grate and is collected in a kettle beneath the retort, from which it is allowed to flow, in a very liquid brown stream, into a receiving pan with a capacity of about twelve thousand pounds, where impurities that were previously held in suspension are allowed to settle to the bottom. From the receiving pan, the sulphur is run into molds shaped like the frustum of a cone, each of which has a capacity of from two hundred to two hundred and fifty pounds. When allowed to stand a few days after cool-

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ing, these cylindrical masses break into irregular lumps, in which condition the sulphur is delivered to the refinery at San Francisco.

DISCUSSION.

The PRESIDENT remarked at some length upon Mr. RUSSELL's paper, giving extended observations of his own in the volcanic rocks of that region.

Remarks were made by several members, and by the PRESIDENT, upon the recent "Forestry Congress," and the great importance of the subjects discussed by that body.

May 29, 1882.

SECTION OF PHYSICS.

The Vice-President, Dr. B. N. MARTIN, in the Chair.

Fifty-seven persons present.

The Secretary exhibited a fresh specimen of the common squid (*Ommastrephes*, sp.), and remarked on the habits, affinities, and geological relations of these animals, and also on the accounts, given by Prof. A. E. VERRILL, of the recent capture of a gigantic specimen on the coast of Newfoundland. Prof. VERRILL reports the length of this individual as nine feet for the body and thirty-five feet for the entire extent, to the ends of the long "arms."

He also referred in the same connection to a story told in a work called "Ocean Wonders" (Appleton & Co., N. Y., 1879), wherein it is asserted that the author, while at Bermuda, had seen an Octopus leave the water and climb a cliff 200 feet high, in pursuit of a red crab (!). This absurd story, so impossible in view of the habits, organization and locomotive apparatus of the cephalopods, is most fully disposed of by a Bermuda naturalist, Mr. J. MATTHEW JONES, as follows:

1. There is no cliff of any kind in Bermuda that is 200 feet high.

2. There is no crab on the Bermuda shores, having a red carapace, during life.

3. The only species of Octopus known at Bermuda never leaves the water.

A paper, by Mr. GEO. N. LAWRENCE, was read by title as follows:

DESCRIPTION OF TWO NEW SPECIES OF BIRDS OF THE FAMILIES COLUMBIDÆ AND FORMICARIDÆ.

This paper appears in the Annals, Vol II., No. 11.

Dr. ELSBERG nominated as a Corresponding Member the lecturer for April last, Chevalier ERNST VON HESSE-WARTTEGG, who was thereupon elected unanimously.

Mr. ROMYN HITCHCOCK then read the following paper, illustrated with a large number of experiments:

RECENT ADVANCES IN PHOTOGRAPHY.

Perhaps it is well to introduce the subject before the Academy in a practical rather than a theoretical form, since photography is a branch of scientific study to which our men of science generally have given but little attention. Yet it possesses great interest for the chemist, who has yet to determine the decompositions which an actinic ray produces in compounds sensitive to light. It affords the student of molecular physics a wide field for investigation. A more profound knowledge of the action of light upon the photographic film will doubtless lead to a deeper insight into the nature of the actinic force itself. Already the photographic plate has enabled us to study the solar spectrum far beyond its visible limits at either end; for not only has it enabled us to record and establish the exact position of the Fraunhofer lines beyond the violet, but, more recently, the spectrum of the red and ultra red has also been portrayed by an ingenious application of well-known facts.

There are three compounds of silver which may be used in the preparation of dry plates, the chloride, the iodide and the bromide. These compounds, being insoluble in water, can be formed by adding a corresponding salt of an alkali to a solution of silver nitrate. They are then precipitated in very minute particles. In each of these three test tubes I place a few drops of a solution of nitrate of silver. To the first one I add a chloride, which gives me a pure white precipitate of chloride of silver. To the second I add a bromide, to the third iodide. The silver bromide is yellow, the iodide is slightly so.

A brief exposure to the light of day changes the color of these salts, and it is this peculiarity which makes them valuable for photography. Years ago, when photography was in its infancy, the problem was to obtain these compounds in a sufficiently sensitive condition to be useful. If we could collect the fine particles, which are suspended in the water in those tubes, before the light has affected them, spread them in a perfectly uniform layer over a sheet of paper or upon a glass plate, and then allow an image to fall upon it in the camera, wherever the light strikes it the color would be changed, and thus a perfect photograph of

the object would be produced. But such a photograph would fade if brought out into the light; besides, it would not be very intense. It is necessary, therefore, to devise some method by which the change produced by the light can be strengthened, and then fixed. In practice, the sensitive compound is obtained upon a glass plate in one of two ways; either by coating the plate with a film of some substance that is permeable to fluids, such as collodion containing a bromide or an iodide, and then dipping the plate thus coated into a bath of silver nitrate, whereby the silver bromide or iodide is formed within the pores of the collodion; or else by precipitating the silver compound in a solution of collodion, gelatin or other medium, in such a manner that the particles will be held in suspension in a state of minute division. By the latter process a so-called emulsion is formed, which is poured over a plate and allowed to dry before use. The causes which affect the sensitiveness of the bromide are still very obscure. It is probable that this is controlled by the physical conditions under which it is formed; in other words, the size of the particles of bromide in the emulsion. The smaller the particles, the more sensitive they are. Yet it seems possible to increase the sensitiveness of an emulsion, by causing the minute particles to become mechanically aggregated into larger masses. At least, this is the explanation suggested by the able experimentalist, Captain Abney, to account for the greater sensitiveness of a gelatin emulsion after boiling. This aggregation of the particles cannot in any wise affect the sensitiveness of the constituent molecules; but, if we can understand how it causes the film to be more sensitive, we will gain an insight into a molecular change which may be said to lie as the foundation of the process of strengthening the image, which is the process commonly known as development.

It has been stated that a perfectly uniform layer of the sensitive silver salt upon a plate would show an image after exposure in the camera. This image results from the decomposition of the sensitive salt into a sub-bromide, sub-iodide or sub-chloride, as the case may be, the bromine, iodine or chlorine being set free; thus $2\ (Ag\ Br) = Ag_2Br + Br$. The change of color, resulting from a short exposure in the camera, is not great; but it is possible to so prepare a plate that the chemical change produced by light in a fractional part of a second suffices to produce an image. Under such circumstances the chemical change must be very superficial, and the decomposition too slight for the eye to detect. Hence, after a plate is properly exposed in the camera, no image is visible upon it. To make the image visible, it must be strengthened or developed.

Before describing the process of development, I will illustrate the process of making an emulsion of silver bromide for the dry-plate pro-

cess. Since the only essential part of this process is the suspension of minute particles of bromide of silver in a suitable fluid, which will dry and form a film upon a plate, we might precipitate the bromide as we did a few moments ago, only in a dark room, and rub it up in a mortar with a solution of gelatin or gum arabic, until a fine, milk-like emulsion is formed. A better method, however, and the one usually followed, I propose to carry out before you now. But first I must explain, that, unless the silver salt can be protected from the action of light, the process must be carried on in a room lighted only by a red light. Without spending any time to explain the reason, I will simply state that potassic bichromate prevents the action of light upon the silver salt, and it is therefore possible to prepare an emulsion in daylight, if this compound is used. After the emulsion is made, the bichromate can be removed by washing in a dark room, when the mixture becomes sensitive to light. I now wish to prepare a gelatin emulsion of silver bromide containing some iodide. [Emulsion prepared.]

After the plate has been exposed in the camera, the image is developed by any one of several methods; but all of them depend upon the fact that, in the presence of what chemists designate as reducing agents —substances which greedily absorb oxygen—a salt of silver is decomposed with the deposition of metallic silver. When such a reducing agent is caused to flow over the plate, the reducing action is most powerful at those places where the light has acted upon the sensitive silver salt and decomposed it. Therefore at such points metallic silver is deposited in very minute, black particles, and, as these increase in quantity, the image becomes visible, acquires density, and details are faithfully brought out.

We can readily illustrate the action of the developer by an experiment. Here is a quantity of silver bromide, which has been precipitated and exposed to sunlight. I have here another precipitate of the same compound, which has been protected from the light. To each of these I will add a developing solution, and you will see the rapidity with which the silver is reduced in one case, and how much more slowly it changes in the other. [Experiment made.] Precisely the same effect is produced in developing the invisible image on the exposed plate. I will now develop a plate which was exposed in my camera, one week ago to-day. It is a stereoscopic view of a modern windmill, which is to be found just above High Bridge. The developer to be used is a mixture of ferrous sulphate, or green vitriol, as it is called, with potassic oxalate, containing some potassium bromide. By mixing the two solutions first mentioned, a solution of ferrous oxalate is obtained, which is the active agent in effecting the reduction, the bromide of potassium being a restrainer—preventing the too rapid and too gen-

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eral reduction of the silver salt. Those who are familiar with photographic process will keep in mind the fact that in developing dry plates, all the silver salt is in the film, while, in the wet plate process, it is customary to mix some silver nitrate with the developer and flood the plate with it. In the case of dry plates the fingers are not soiled during this process, while with wet plates they are sure to be blackened by the silver. [Plate developed.]

The time is so limited that I cannot discuss and explain the chemical process of developing a picture as fully as I would wish. I am quite sure that if we were to spend the entire evening in considering this single operation, there would be no lack of interest on the part of this audience. In studying the process of development, explaining how the invisible image is intensified and brought out in all its details, we are dealing with chemical changes which are so slight as to almost baffle our efforts to detect them. The light acts upon the molecules of the the silver salt in the plate, perhaps only the $\frac{1}{10000000}$ part of a second of time; but that is enough to overcome, or in some way to weaken, the force which binds together the constituent atoms. When the developing solution is applied, each particle of silver salt that has been thus changed, acts, we may say, as a nucleus to start the action of the developer. The tendency of the latter, as already stated, is to reduce any silver salt that may be present; but if a soluble bromide, such as potassium bromide, be present in sufficient quantity, this tendency is restrained, and no reduction will take place, unless the action is started by the partially decomposed silver salt. The balance of the chemical forces is so perfect in a well-made developer, that wherever there is a molecule of silver bromide on the plate which the light has affected, there decomposition takes place and black metallic silver is deposited, while all the rest of the plate remains white. Thus every line and every shadow and half-tint in an object is faithfully reproduced in the photograph.

After development there remains upon the plate a quantity of unchanged bromide of silver, which must be removed or the light would act upon it, and destroy the picture. The picture must, therefore, be fixed by dissolving the unchanged silver salt in sodic hyposulphite. [Plate fixed.]

In the short account that has been given of the preparation and development of dry plates, no allusion has been made to many questions of great theoretical interest, which I hope to make the subject of a future article. It has seemed best to confine this article to the strictly practical part of the subject; and I now wish to speak more particularly of the advantages of the dry-plate process, not for the photographer in business, but for the traveller and explorer, the naturalist and the student in various branches of science.

The great advantage of the process for all these purposes is to be found in the sensitive plates. They can be purchased ready for use in the camera, and will remain good for any length of time. They may be carried across the continent, exposed in a camera on the top of a mountain hundreds of miles from civilization, or in the interior of an unexplored country, then packed away in light, tight boxes, and the pictures developed months afterward in this city. In this way the geological and topographical features of a country may be accurately reproduced on paper, or, by means of glass positives, thrown upon a screen for the illustration of a lecture. The botanist may photograph a rare plant in bloom in distant lands, and the traveller in Central Africa, for instance, may portray the features of the natives he finds, with far more truthfulness than with pencil and brush.

In the laboratory, the student of physics will find many uses for photography. Already, it has been applied to the study of spectra, with great advantage, and lately the electric spark has been photographed, with an exposure, it is said, of only $\frac{1}{1000000}$ of a second.

[The method of making instantaneous pictures was then described, and the apparatus was exhibited. After the Academy adjourned, the process of making positives on glass for use in a lantern was illustrated by placing a negative over a sensitized plate in a deep printing-frame, and exposing it to the light of an argand lamp for about ten seconds, after which the picture was developed and fixed in the usual way.]

June 5, 1882.

REGULAR BUSINESS MEETING.

The President, Dr. J. S. NEWBERRY, in the Chair.

Forty-five persons present.

The report of the Council was read, recommending

1. The election of the following persons, previously nominated as Resident Members:

J. K. FUNK, W. H. MEAD,
HOWARD WAINWRIGHT, ALEXANDER WARNER.

2. That when the Academy adjourns, it shall be to October 2.

The four persons named were unanimously elected, and the recommendation for the usual summer adjournment was agreed to.

The PRESIDENT showed teeth of *Carcharodon*, measuring five inches by six, from the tertiary "Phosphate beds" of South Carolina. This is about the maximum size ever known for fossil shark-

teeth. The modern "white shark" is some five feet long and if the proportion was the same between the size of the teeth and the whole body in the ancient *Carcharodon*, its size must have been fully fifty feet. It is noteworthy that very large teeth of similar character, but in quite a fresh condition, were dredged up in the depths of the Pacific by the "Challenger" party; which fact would indicate that this species, or one closely akin to it, had survived in the deep waters, at least until quite recently.

He also exhibited an ingot of aluminium, two inches by six, obtained by a new process, at much lower rates than had heretofore been possible, and remarked upon the many important uses for aluminium, if its cost could be reduced.

The following papers, by Mr. THOMAS BLAND, were read by title:

I. DESCRIPTION OF TWO NEW SPECIES OF ZONITES FROM TENNESSEE.

II. NOTES ON THE DISTRIBUTION OF GENERA OF TERRESTRIAL MOLLUSKS IN THE WEST INDIES.

Dr. WESLEY MILLER read a paper entitled:

THE PREVENTION OF TUBERCULAR DISEASE IN MEN AND ANIMALS BY VACCINATION.

He discussed the general theory of inoculation and vaccination, and referred to experiments made by himself, and to be further carried on, as to the reduction of virulence attainable by artificial propagation of virus through many generations, in the bodies of domestic animals.

Dr. N. L. BRITTON read the following paper:

ON SOME LARGE POT-HOLES, NEAR WILLIAMSBRIDGE, N. Y.

The "pot-holes" which I shall attempt to describe were first brought to my notice by the late Prof. A. WOOD. They are located on the western bank of the Bronx River, about midway between Bronxdale and Williamsbridge, Westchester County, New York. They are near the western end of a now dismantled and impassable bridge, with stone abutments, and in the northern part of a hemlock grove which fringes the stream for about a mile below. It is one of the most picturesque spots in the vicinity of New York City, and a walk along the little river from Bronxdale to Williamsbridge is always enjoyable.

The Bronx "River," as it is called, though the term gives it an importance which it does not possess, is a stream about 40 to 50 feet

wide, rising in Westchester County, and discharging its waters into Long Island Sound, nearly opposite College Point.

It occupies, however, the bottom of a valley, which, at Williamsbridge, must be at least half a mile wide, probably more, and two hundred feet deep below the summits of the hills which bound it to the east and west. This great depression extends northwardly with the river, but I have not studied it any further north than White Plains, where it is quite broad. At a point about three-fourths of a mile below the Williamsbridge station of the Harlem Railroad, this valley is somewhat narrowed, and much interrupted by a ridge of rock running parallel with the present course of the stream, viz., very nearly north and south. The Bronx flows through a narrow gorge cut out of this rock. It is near the northern end of this ridge where the pot-holes under consideration are situated. Leaving the train at Williamsbridge, and ascending the stream, we pass through a stretch of swampy ground of considerable botanical interest, it being the only known habitat about New York for *Arisæma Dracontium*, the "green dragon," we pass the old bridge before mentioned, and enter the grove of hemlock. The first pot-hole to be observed is quite imperfect, only a portion of the western side now remaining, the rest having been broken away. It bears S. 50° W. from the western end of the bridge, at a distance of 76 feet. The bottom of the pot is about 18 feet above the present level of the Bronx at this point, but this is less than the natural height would be, as the water is backed up by a dam half a mile below. Measurements indicate that the total depth of the hole must have been about nine feet, and at half its height the diameter not less than ten feet. This must, however, have very rapidly decreased towards the bottom.

Proceeding 136 feet south from the bridge, and then up the rocks to a point 63 feet from the river bank, the second pot will be found. This is much more perfect, and is quite a noticeable object. The bottom of this one is twenty or twenty-two feet above the present water level. The hole is oval in section, about four-fifths of the original outline still remaining, only the outer (the eastern) end being broken away. Its dimensions are as follows:

Total indicated depth, 10 feet.
Depth of nearly perfect lower part, 4′ 6″.
Depth of entire basin at the bottom, 10″.
Shortest diameter, 5′.
Original longer diameter probably about 6′.
Distance from back to broken face, 4′ 7″.

The lower part of this pot is very well preserved; the bottom and sides are very highly smoothed, indeed quite polished. The upper por-

tion, where the wear began, is now represented only by a portion of the rock surface about 5′ high and 2′ long, which is concave and smooth.

Some fifty feet southwest of this hole, and fifteen feet above it, there are two other vertical pieces of rock with smoothed and somewhat concave surfaces, which, perhaps, may be remains of others, but they are too imperfect to warrant any description.

The rock, in which these pot-holes are situated, is a compact fine-grained gneiss, with black mica. It is very much broken up by horizontal and vertical cleavage planes. There are not very many loose blocks, however, these having been carried away to the south by the glacier of the ice period. The natural strike of the strata in the vicinity is S. about 18° W. The dip is nearly vertical, being in the neighborhood of 85° N. W.

The history of the formation of these holes may be briefly outlined as follows: that, in pre-glacial times, the valley through which the Bronx now flows was occupied by a large stream, which was expanded into a broad and deep comparatively slow-moving body of water, above the point where the holes are now situated; but, at and below this point, it became a rapid, turbulent and shallow river, whose level, as shown by the position of the holes, must have been at least thirty feet above that of the present one; that the holes were produced, as they have been shown to be in other localities, by the grinding action of some harder stone on the gneiss rock, this stone being kept in a whirling motion by an eddy in the current. During the ice period the valley was deepened, and the narrow gorge, through which the waters of the Bronx now pass from below Williamsbridge to Bronxdale, was excavated, the ice sheet having carried the debris southwardly and deposited it on the terminal moraine running through Long Island. I am informed by Prof. J. D. HYATT that there are two other pot-holes, rather imperfectly preserved, near the village of West Farms, about two miles south of those described, in the same valley.

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